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PATENT APPLICATION

UNITARY SLOT VALVE ACTUATOR WITH DUAL VALVES AND METHOD FOR IMPLEMENTING THE SAME

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BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to valves for modules of semiconductor processing equipment, and more particularly to a unitary slot valve actuator with dual slot valves and methods of implementing such valves between separate chambers of semiconductor processing equipment so that operations may continue in one chamber during servicing of the other chamber, which semiconductor equipment may be a multi-chamber vacuum system.

2. Description of the Related Art

In vacuum processing of thin film materials, such as in the manufacture of semiconductor devices, multiple process chambers are interfaced to permit transfer of wafers, for example, between the interfaced chambers. Such transfer is via transport modules that move the wafers, for example, through slots or ports that are provided in the adjacent walls of the interfaced chambers. For example, transport modules are generally used in conjunction with a variety of substrate processing modules, which may include semiconductor etching systems, material deposition systems, and flat panel display etching systems. Due to the growing demands for cleanliness and high processing precision, there has been a growing need to reduce the amount of human

interaction during and between processing steps. This need has been partially met with the implementation of transport modules which operate as an intermediate handling apparatus (typically maintained at a reduced pressure, *e.g.*, vacuum conditions). By way of example, a transport module may be physically located between one or more clean room storage facilities where substrates are stored, and multiple substrate processing modules where the substrates are actually processed, e.g., etched or have deposition performed thereon. In this manner, when a substrate is required for processing, a robot arm located within the transport module may be employed to retrieve a selected substrate from storage and place it into one of the multiple processing modules.

As is well known to those skilled in the art, the arrangement of transport modules to "transport" substrates among multiple storage facilities and processing modules is frequently referred to as a "cluster tool architecture" system. Figure 1 depicts a typical semiconductor process cluster tool architecture 100 illustrating the various chambers that interface with a transport module 106. Transport module 106 is shown coupled to three processing modules 108a-108c which may be individually optimized to perform various fabrication processes. By way of example, processing modules 108a-108c may be implemented to perform transformer coupled plasma (TCP) substrate etching, layer depositions, and/or sputtering.

Connected to transport module 106 is a load lock 104 that may be implemented to introduce substrates into transport module 106. Load lock 104 may be coupled to a clean room 102 where substrates are stored. In addition to being a retrieving and serving mechanism, load lock 104 also serves as a pressure-varying

interface between transport module 106 and clean room 102. Therefore, transport module 106 may be kept at a constant pressure (*e.g.*, vacuum), while clean room 102 is kept at atmospheric pressure. To prevent leaks between modules during pressure varying transitions, or to seal off a processing module from transport module 106 during processing, various types of gate drive valves are used to isolate the various modules.

For more information on gate drive valves, reference may be made to U.S. Patent No. 4,721,282, which is hereby incorporated by reference. Another such gate drive valve is shown in U.S. Patent 5,667,197, in which a prior art valve housing is shown having two port openings, and only one valve for one of the two port openings. Thus, it is not possible to close the port that does not have an associated valve. Also, the gate plate valve of the '282 Patent is shown for closing a port between abutting transport and process chambers, and no intermediate valve housing is provided. A drive assembly for the gate plate moves the gate plate in one continuous motion in a vertical path and in a rotating arc toward the internal port to effect a seal or closure of the internal port.

U.S. Patent 5,150,882 shows one valve between various chambers of a treatment system, including between a decompression chamber and an etching chamber. Such one valve is driven for engagement and disengagement with a gate aperture by one air cylinder and a toggle arrangement such that stopper plates hit rollers with considerable impact. Initial vertical movement of a fitting plate is changed to horizontal movement by the link that is rotated counterclockwise, such that the gate moves toward the gate aperture. For the '882 Patent to avoid problems of the prior art, the stopper plates are made from a double boride hard alloy. Further,

the single motion of the one air cylinder is not stopped, but instead continues its driving operation after the abutment of the stopper plates with the rollers. Thus, in addition to requiring special materials, the '882 Patent does not provide two valves between adjacent processing chambers.

Other valves for cluster tool architecture systems include a separate actuator for each of two valves, which tends to increase the width of a valve actuation housing or, when attempts are made to reduce such width, to restrict the location at which force is applied by the actuators to the valves. Also, such valves require a separate bellows for each of the two separate actuators. Because the cost of such bellows is substantial (e.g., in the range of $800.00 to $1000.00 each, in year 2000 U.S. dollar terms), it is costly to require two bellows. Further, each such separate actuator is generally driven by a separate pneumatic cylinder, which also increases costs when one separate actuator is required for each of the two valves.

In view of the forgoing, what is needed is a valve assembly between adjacent process or transport chambers, wherein operations in one such chamber may continue while servicing, for example, is performed in the other chamber, and wherein the valve assembly has only one common valve actuator for two valves, thus reducing the cost of the assembly by eliminating one bellows and two pneumatic drives.

SUMMARY OF THE INVENTION

Broadly speaking, the present invention fills these needs by providing a dual sided slot valve in a housing between adjacent chambers or modules, such as a transport chamber and a process chamber. Separate valves are provided for each of two valve housing ports or slots, such that one housing port adjacent to the process chamber or one housing port adjacent to the transport chamber, for example, may be selectively closed while the other port remains open. For example, the selectively closed valve facilitates maintaining a vacuum, for example, in a transport chamber while an adjacent process chamber is opened to the atmosphere to allow servicing to be performed. As a result, substantial periods of downtime are avoided in that no pump-down cycle is needed to bring the transport chamber to a desired vacuum after servicing the process chamber, and no other operations need be performed on the transport chamber due to the servicing of the process chamber.

Also, with the valve to the transport chamber closed so that the transport chamber is at vacuum, the passage of debris (such as broken wafers) from the open process chamber may be blocked by the open valve to the process chamber so that such debris does not contaminate the transport chamber. Thus, in general, only the valve door next to the process chamber need be replaced during servicing after it becomes corroded, and the transport chamber may remain at vacuum during such replacement.

Further, the dual sided slot valve is provided with these advantages while initially allowing easy access to one or both open valve(s) for performing service on the open valves. Such easy access is provided by a common actuator operated by first

and second drives. To close one valve, the first drive is actuated and stops with the one valve closed and the other valve in an open, but not laterally-spaced (i.e., not vertically-spaced), position relative to the respective port. If both valves are to be serviced, the first drive is not actuated and the open position of each valve is maintained by a spring-loaded assembly that holds the actuator centered in an open actuator position. In this open position the open valve or valves may be reached by a gloved hand of a worker for service. The second drive may function to move the actuator and cause both of the valves to move laterally (e.g., downwardly) away from the open position and away from the respective ports. The laterally-moved open valves expose the sealing surface around the ports, which permits cleaning of the sealing surfaces, for example. Due to the vertical distance between the laterally-moved valves and an access opening (which is normally closed by a lid), it is generally difficult for the protective glove of the worker to reach the valve for service after the vertical movement. In the laterally (vertically)- moved position, however, the valves do not interfere with the ability to clean around the valve doors, including the surfaces against which the doors seal.

Additionally, only one common actuator is provided for both of the slot valve doors so as to reduce the clean room real estate occupied by the valve housing between the adjacent transport and process chambers, for example. Also, such common actuator applies force to each of the slot valve doors at a central location of the slot valve door, which reduces the force required to maintain the slot valve door closed. Further, with only one actuator, only one bellows is required, as compared to the valve assemblies that have two actuators and that thus require two bellows.

It may be understood, then, that while normal operations continue in one chamber of two adjacent chambers, many types of servicing may be performed in the other of the two chambers. Such servicing may, for example, include removing broken pieces of wafers from a chamber or the valve housing, cleaning the sealing surface of a port, cleaning the interior of a chamber, and removing and replacing a member of a valve (*e.g.*, a door or an O-ring) that effects the seal with the sealing surface. These and other operations for maintaining such chambers in normal operation for semiconductor processing, for example, are referred to herein as "servicing," or "service."

Other aspects and advantages of the invention will become apparent from the following detailed description, taken in conjunction with the accompanying drawings, illustrating by way of example the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be readily understood by reference to the following detailed description in conjunction with the accompanying drawings, in which like reference numerals designate like structural elements.

Figure 1 depicts a typical prior art semiconductor process cluster tool architecture illustrating various process modules that interface with a transport module, wherein a single door valve is in one process or transport module such that the process and transport modules each must be shut down to enable servicing of either of the them.

Figure 2 depicts a dual sided slot valve of the present invention located between adjacent ones of a transport module and a process module, wherein two door

valves are in a valve vacuum body of a valve housing between the transport and process modules, such that only a selected one of the modules need be shut down to enable servicing of the selected one of them.

Figure 3 is a plan view of a dual sided slot valve of the present invention showing the valve vacuum body having a width defined by opposite walls, and a slot in each wall to permit wafers to be transferred from a transport module to a process module, wherein one slot may be selectively closed by one of the two doors upon operation of a common actuators to permit continued operations within the one module while the other module is being serviced.

Figure 4A is a schematic diagram of a controller for controlling the movements of a respective first door and a respective second door of the valve, wherein the controller is coupled to a computer workstation that is used to operate the dual slot valve.

Figure 4B depicts three switches for providing input to the controller to facilitate controlling the movements of the first door and the second door of the valve.

Figure 5 is a vertical view of the dual sided slot valve of the present invention showing the common actuator including an open/close air cylinder which rotates a cradle to move one of the doors into an OPEN or a CLOSED position, wherein the common actuator also includes an up/down air cylinder which moves the doors relative to the slots when the doors are in the OPEN position and aligns the doors with a slot or moves the doors below the slots.

Figure 6A is a vertical cross-sectional view showing the two dual sided slot valves of the present invention in an OPEN and UP position, and showing the

common actuator carrying the two doors, wherein the common actuator has the two separately controllable motions to permit selected servicing operations to be performed on the process module, for example, while operations continue within the transport module.

Figure 6B is a vertical cross-sectional view similar to Figure 6A showing one valve door of the present invention in a CLOSED and UP position to facilitate servicing of the other valve door.

Figure 6C is a vertical cross-sectional view similar to Figures 6A and 6B showing the two valves of the present invention in a DOWN and OPEN position to facilitate servicing of the valve slots.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

An invention is described for methods and apparatus that ensure that operations may continue in one module of a semiconductor process cluster tool architecture during servicing of another module. The invention is described in terms of valves for modules of semiconductor processing equipment, and more particularly to a unitary slot valve actuator with dual valves and methods of implementing such valves between separate modules of semiconductor processing equipment. It will be obvious, however, to one skilled in the art, that the present invention may be practiced without some or all of these specific details. In other instances, well known process operations have not been described in detail in order not to obscure the present invention.

Referring to Figure 2, the invention is generally described as including a semiconductor process cluster tool architecture 200 having a transport module 202 and process modules 206, wherein a dual sided slot valve 204 is located between adjacent ones of the transport module 202 and the process module 206. Considering Figure 2 as a plan view, a footprint of the architecture is defined by the combined floor area of the transport module 202, the process modules 206, and the dual sided slot valves 204. It may be understood that the floor areas of the transport module 202 and the process modules 206 may be primarily dictated by considerations other than the manner in which the modules 202, 204 and 206 are sealed together for operations. The individual dual sided slot valves 204 define the manner in which the modules 202 and 206 are sealed together for operations, such that the footprint of each individual dual sided slot valve 204 becomes significant in attempts to reduce the footprint of the

cluster tool architecture 200. Thus, to reduce the footprint of each individual dual sided slot valve 204 it is important to reduce the width W of each of the individual dual sided slot valves 204 as much as possible.

Figure 3 shows one of the dual sided slot valves 204 of the invention as including a valve vacuum body 212 located between two modules of the cluster tool architecture 200. As shown, the two modules are the transport module 202 and one of the process modules 206, it being understood that valve vacuum body 212 (or housing) may be located between any two modules of the cluster tool architecture 200. The valve vacuum body 212 has the width W defined by opposite walls 214. The side of each wall 214 nearest to the process module 206 may be referred to as the "PM side," whereas the side of each wall 214 nearest to the transport module 202 may be referred to as the "TM side." The valve vacuum body 212 has a length L defined by opposite end walls 216, where the width W times the length L defines the footprint of the individual dual sided slot valve 204.

A port (or slot or opening) 218 is provided in each wall 214 to permit wafers (not shown), for example, to be transferred between one module and another module. As shown in Figure 3, one such module is the transport module 202 and the other such module is the process module 206, with the slot 218P being adjacent to the process module 206 and the slot 218T being adjacent to the transport module 206. Each of the slots 218 is generally rectangular in shape and is smaller in each dimension than the generally rectangular shape of a door (or side door) 222 provided for closing the respective slot 218. In the case of the doors 222 and the slots 218, the corners are rounded, thus the respective rectangular shapes are referred to as "generally rectangular." Each of the doors 222 has a seal periphery 224 that overlaps

an opposing seal surface 226 of the opposing wall 214 of the body 212. The seal periphery 224 may be provided with a seal device such as an O-ring 228 which is pressed against the seal surface 226 to provide a vacuum-tight, or gas-tight, seal when the door 222 is in a CLOSED position as described below. Alternatively, a seal device may be vulcanized to the door 222, or another type of seal device having a replaceable seal may be used. The door 222-2 at the wall 214 forms a pressure seal between the transport module 202 and the process module 206. In this manner, the PM side, for example, may be vented to atmosphere while the TM side remains at normal vacuum level (*e.g.*, 80 – 100 mTorr). The valve 204 is also designed to allow the transport module 202 to be vented while the process module 206 is at vacuum, or to allow the process module 206 to be vented while the transport module 206 is at the vacuum level.

Referring to one of the doors 222, described as the door 222-1 and shown for example at the right as viewed in Figure 3, the respective slot 218P may be selectively closed upon operation of one of a common actuator 232. Use of the common actuator 232 permits, for example, continued operations within the transport module 202 while the process module 206, for example, is being serviced. Therefore, only a selected one of the transport module 202 and the process module 206 need be shut down to enable servicing of the selected one of them. One result of actuation of the common actuator 232 is to locate either door 222 in a CLOSED position, or in an OPEN position as shown in Figure 3. In the OPEN position, either door 222 defines a space 234 between the door 222 and the wall 214. Another type of actuation of the actuator 232 is to locate the doors 222 in either a DOWN or an UP position, which positions are along a Z-axis shown in Figure 3.

Figure 4A shows the transport module 202, the process module 206, and one of the dual sided slot valves 204. A controller 402 is connected to, and controls, the operation of the valve 204, including operation of the common actuator 232 for controlling the doors 222-1 and 222-2. The controller 402 is connected to a computer workstation, or tool-embedded controller, 404. The controller 402 interfaces with the valve 204 via an electronics unit 406. Figure 4B shows the top of the electronics unit 406 provided with a series of switches 408, 410, and 412, which are respectively for controlling the movement of the doors 222 into the OPEN and CLOSED positions, for controlling the movement of the doors 222 into the DOWN and UP positions, and for selecting which of the modules 202 and 206 is to be serviced (e.g., process module 206 is "PM"; and transport module 202 is "TM"). Examples of the signals 414 transmitted between the controller 402 and the slot valve 204 are "Open Door" and "Close Door".

The common actuator 232 is shown in Figures 5, and 6A – 6C supporting the two doors 222-1 and 222-2. The X axis designates the arcuate path along which the doors 222 move from the CLOSED position of the door 222-1 shown in Figure 6B moving to the left to the OPEN position of both doors 222 shown in Figure 6A. The X-axis may be generally perpendicular to the planes of the walls 214. Figures 6A – 6C show that although the path of the doors 222-1 and 222-2 is arcuate relative to a cradle axis-C, the radius of the arc is large enough that the OPEN position of the doors 222 may be said to be perpendicular to and away from the side walls 214 of the body 212. In the OPEN position, the doors 222 define the spaces 234 between the respective door 222 and the respective wall 214. With the doors 222 in the OPEN position, the easy access to the valve 204 for service, as noted above, is provided.

The advantage of initially allowing easy access to the valve 204 in the OPEN and UP position shown in Figure 6A, which position is not vertically down (i.e., not laterally-spaced), is that in the OPEN and UP position the doors 222 of the valve 204 may be reached by a gloved hand (not shown) of a service worker for service when a lid 236 is removed from the body 212.

The Z-axis corresponds to the above-referenced vertical, or lateral, direction or spacing, and is also shown in Figures 5, and 6A – 6C. The Z-axis is the axis of the actuator 232 along which the doors 222 move into the UP and DOWN positions relative to the ports 218. Comparing Figure 6A to Figure 6B, it may be appreciated that the Z-axis moves, and in particular, rotates on the cradle axis C from a vertical orientation (Figure 6A) to a tipped orientation (Figure 6B) at an angle T with respect to vertical. The change in orientation around the C-axis, and the distance A from the C-axis to the center of the doors 222, result in the doors 222 moving from the CLOSED position, Figure 6B (at which the O-ring touches the seal surface 226), to the OPEN position, Figure 6A, wherein the doors 222 are separated by the spaces 234 from the walls 214.

The actuator 232 includes the upper valve vacuum body 212 mounted on top of a bottom plate 302. The body 212 has the slots 218P and 218T aligned with the X-axis, and is adapted to be sealed by the lid 236. A lower end 304 of a bellows 306 is sealingly attached to the bottom plate 302. An upper end 308 of the bellows 306 is sealingly attached to a bellows plate 310. With the bellows 306 sealed to the bottom plate 302 and to the bellows plate 310, and with the lid 236 sealed to the top of the valve vacuum body 212, the body 212 is strong enough to resist the forces of a

vacuum applied through the slot 218P, for example. The bellows 306 has a hollow cylindrical shape defining a cavity 312.

The bottom plate 302 carries four spaced arms 316 of a pivot frame 318. Two arms 316 extend downwardly to the left from the bottom plate 302 below the bellows 306. Another two of the arms 316 extend to the right from the bottom plate 302 below the bellows 306. Each opposite pair of arms 316 join at a bridge 319 and a base 320. Each bridge 319 supports a pivot pin 321 that is centered on the C-axis. The pivot pin 321 provides a rotary mount for a cradle 322 having opposite arms 323 shown in Figure 5 as being suspended from the respective pins 321 for rocking motion around the C-axis. The rocking motion is provided by a double-acting first pneumatic motor 324 having an open/close cylinder 326, and a piston rod 328. The motor 324 is secured to the arms 316 by a bridge 329. One end of the piston rod 328 is secured to a pin 330 that is received in slots 331 so that when the piston rod 328 is retracted or extended the cradle 322 respectively rotates counterclockwise or clockwise on the C-axis. The retracted piston rod position shown in Figure 6B corresponds to, and causes, the OPEN position of the door 222-2 since the piston rod 328 causes the cradle 322 to rock clockwise on the pin 321. That retracted position also corresponds to and causes the CLOSED position of the door 222-1. It may be understood that a fully extended piston rod position (not shown) corresponds to, and causes, the CLOSED position of the door 222-2 since the piston rod 328 causes the cradle 322 to rock counterclockwise on the pin 321. A neutral position of the piston rod 728 is shown in Figures 6A and 6C and corresponds to and causes the simultaneous OPEN positions of both of the doors 222.

The cradle 322 also supports an up/down cylinder 334 of a second, or up/down motor 336. With the cylinder 334 fixed to the cradle 322 by opposite motor mounts 337, a piston rod 338 may be extended or retracted and slides through bearings provided in an opening 340 in the plate 302. The bellows 306 has the cavity 312 with a hollow cylindrical shape for receiving a door-mount section 341 of the piston rod 338. As shown in Figures 6A – 6C, such bearings allow the piston rod 338 of the second, or up/down, motor 336 to be extended or retracted and correspondingly move the bellows plate 310 up or down. The bellows plate 310 carries the door-mount section 341 which supports the two doors 222-1 and 222-2 for rotation on hinge pins 342. The door-mount section 341 is attached to the doors 222 centered with respect to a mid-point of each door 222, such that each of the doors 222 is supported by the section 341 centered about the longer side (or Y-axis dimension) of each respective door 222. As a result of the centered mounting of the doors 222 to the door -mount section 341, the closure force F in the direction of the X axis applied by the door-mount section 341 to each door is uniformly applied to each door 222, yet the one common actuator 232 enables the width W of the body 212 to be substantially reduced from that of valves in which two separate actuators are provided in a valve body. In practice, the width W of the body 212 need only be about six and one-half inches, for example.

It may be understood from Figures 6A and 6C that when the piston rod 338 of the up/down motor 336 is extended, the doors 222 are in the UP position (Figures 6A and B) with the bellows 306 extended. When the piston rod 338 of the up/down motor 336 is retracted the doors 222 are moved into the DOWN position (Figure 6C) with the bellows 306 retracted. It may be understood then, that the common actuator

232, with the separate motors 324 and 336, operates to simultaneously move the doors 222 in a first direction of the X-axis generally perpendicular to the respective first and second walls 214-1 and 214-2 of the body 212, and to simultaneously move the doors 222 in a second direction generally parallel to the walls 214 of the body 212.

As described above, the piston rod 328 has a neutral position shown in Figure 6A. The neutral position corresponds to the OPEN position of the doors 222. When the piston rod 328 is in the neutral position the motor 324 is not actuated, such that there is no pneumatic fluid pressure on the piston rod 328 in either the left or the right direction. Figures 5 and 6A - 6C show an actuator bias assembly 350 provided for keeping the piston rod 328, and thus the cradle 322 and the common actuator 232, in the neutral position centered between the sides 214 of the body 212. In Figures 6A - 6C, the cradle 322 is shown mounted for the swinging motion between the opposite stationary arms 316. Figure 5 shows the base 320 having the actuator bias assembly 350 centered with respect to the Z axis. The assembly 350 includes opposite bias sections 352 mounted generally at the bottom of each arm 316. Each bias section 352 includes a bore 354 in the base 320 for receiving a bias plunger 356 for left and right movement with or against the force FB of a resilient member 358 such as a spring.

A threaded plug 360 is screwed into a threaded end 362 of the bore 354 to hold the bias plunger 356 in the bore 354. The bore 354 is provided with a shoulder 364 which limits the motion of the bias plunger 356 in the bore 354. Each of the two actuator bias assemblies 352 may exert the force FB in an opposite direction (parallel to the X axis) against the cradle 322, such that the oppositely directed forces FB cause

the cradle 322, and the common actuator 232 in the neutral position centered between the sides 214 of the body 212, to be in force equilibrium.

Each force FB is sufficient to overcome the frictional and other forces in the motor 324 when there is no pneumatic force on the piston rod 328. In this manner, the separate bias sections 352, in applying the respective leftward and rightward forces FB on the cradle 322, resiliently maintains the cradle 322 in the neutral position shown in Figures 6A and 6C. Each such force FB may be overcome when the motor 324 is appropriately actuated against such force FB. Thus the force of the motor 324 may overcome the respective bias section force FB and either cause left swinging (Figure 6B) or right swinging of the lower portion of the cradle 322 around the pin 321. The door-mount section 341 moves oppositely from the lower portion of the cradle 322 as shown in Figures 6B, for example, where the right door 222-1 is shown moved to the right and CLOSED position corresponding to the lower portion of the cradle 322 moved to the left against the force FB from the left actuator bias section 352.

The unmet needs of the prior art cluster tool architecture 100 are filled by the above-described dual sided slot valve 204 in the vacuum body 212 between the adjacent modules 206 and 202, such as the transport module 202 and the process module 206. One of the separate doors 222 is provided on the common actuator 232 for each of the two valve housing ports 218, such that one housing port 218P adjacent to the process module 206 and one housing port 218T adjacent to the transport module 202, for example, may be selectively closed while the other port remains open. For example, the selective closure facilitates maintaining a vacuum in the transport module 202 while one adjacent process module 206 is opened to the

atmosphere to allow servicing to be performed. As a result, substantial periods of downtime are avoided in that no pump-down cycle is needed to bring the transport module 202 to a desired vacuum after servicing the one process module 206, and no other operations need be performed on the transport module 202 due to the servicing of the process module 206. Also, operations in the transport module 202 can continue uninterrupted. Thus, the total productivity of the cluster tool architecture 200 is enhanced because by keeping the transport module 202 under vacuum, one allows production to continue using the transport module 202 while servicing of the one process module 206 is performed.

Also, with the door valve 222-2 to the transport module 202 closed so that the transport module may be at vacuum, the passage of debris (such as broken wafers, not shown) from the open process module 206 may be blocked by the open door valve 222-1 associated with the process module 206 so that such debris do not contaminate the transport module 202. In addition, debris-blocking tabs 380 may be mounted within the body 212 above the doors 222 to further prevent the passage of the debris from the open process module 206, for example. Thus, in general, only the valve door 222-1 next to the process module 206 need be replaced during servicing after it becomes corroded, and the transport module 202 may remain at vacuum during such replacement.

Further, the dual sided slot valve 204 is provided with these advantages while initially allowing easy access to one or both open door valve 222 for performing service on the open door valves 222. Such easy access is provided by the common actuator 232 operated by the first and second drives 324 and 336. To close one door valve 222, the first drive 324 is actuated and stops with the one door valve 222 in the

CLOSED position and the other door valve 222 in the OPEN position, and both door valves 222 in the UP position. If both valves are to be serviced, the first drive 324 is not actuated and the OPEN, centered position of each door valve 222 is resiliently maintained by the actuator bias assembly 350 that holds the common actuator 232 centered in the open-actuator position. In this OPEN position the open door valve 222 or door valves 222 may be reached by a gloved hand of a worker for service. The second drive 336 may function to move the common actuator 232 and cause both of the door valves 222 to move laterally (i.e., downwardly) away from the OPEN position and away from the respective ports 218 to expose the sealing surface 226 around the ports 218. Such exposure permits cleaning of the sealing surfaces 226, for example.

Due to the vertical distance between the laterally-moved door valves 222 and an access opening 262 (which is normally closed by the lid 236), it is generally difficult for the protective glove of the worker to reach the door valves 222 for service after the vertically downward movement. In the laterally downward moved position, however, there is a clear line of sight between the ports 218T and 218P such that the door valves 222 do not interfere with the worker's ability to clean around the door valves 222, including the surfaces 226 against which the door valves 222 seal.

Additionally, only one common actuator 232 is provided for both of the slot valve doors 222 so as to reduce the width W and thus reduce clean room real estate occupied by the valve housing 212 between the adjacent transport module 202 and process module 206a, for example. Also, such common actuator 232 applies the force F to each of the slot valve doors 222 at the central location of the slot valve door 222, which reduces the value of the force F required to maintain the slot valve door 222

closed. Further, with only one common actuator 232, only one bellows 306 is required, as compared to other valve assemblies that have two actuators and that thus require two bellows.

It may be understood, then, that while normal operations continue in one module (e.g., 202) of two adjacent modules 202 and 206a, many types of servicing may be performed in the other of the two modules (e.g., one adjacent process module 206). Such normal operations may, for example, allow use of the transport module 202 with another process module 206 that is also adjacent to the transport module 202, enhancing the total, or overall, productivity of the cluster tool architecture 200. Such servicing may, for example, include removing broken pieces of wafers from the one process module 206a or the valve housing 212, cleaning the sealing surface 226 of a port 218, cleaning the interior of the one process module, and removing and replacing a member of a valve 204 (*e.g.*, a door 222 or an O-ring 228).

Although the foregoing invention has been described in some detail for purposes of clarity of understanding, it will be apparent that certain changes and modifications may be practiced within the scope of the appended claims. Accordingly, the present embodiments are to be considered as illustrative and not restrictive, and the invention is not to be limited to the details given herein, but may be modified within the scope and equivalents of the appended claims.